IDEA-0111-68
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15 February 1968

MEMORANDUM FOR THE RECORD

SUBJECT: U-2R Development Status and Technical Meeting, 1 February 1968

1. Summary Report:

a. The Lockheed projection of the flight schedule for aircraft number one and number two indicates that all of the required development test objectives will be completed in March with the exception of the tracker camera and the "H" camera tests. These exceptions are due to slippages in the delivery schedules for the hatch windows.

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b. [redacted]

c. On the last flight of the number one aircraft, prior to this meeting, the pilot experienced a very noticeable shaking in the aft end of the fuselage. Lockheed has a theory to explain the incident but have not yet verified this theory. This incident occurred at V=234 knots and altitude = 37,000 feet. Until confirmation of the cause and any required fix is accomplished the aircraft will be restricted to a maximum V=210 knots at 37,000 feet altitude.

d. A design change in the hydraulic system has been incorporated to eliminate the numerous hydro pump failures of past flights.

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e. The emergency brake system circuit has been redesigned to provide emergency brakes even if electrical power is lost.

f. Instrumented data from flight 21 of the number one aircraft indicate excellent agreement between predicted and actual maximum power range factors and altitudes for a mission of approximately four hours duration.

2. Detailed Report:

On 1 February 1968 a technical meeting was held at Lockheed, Burbank, for the purpose of reviewing the status of the U-2R development and flight test program. Attached herewith is a copy of the briefing charts used by Mr. Johnson during the meeting. These charts are generally self explanatory. Several areas of significant interest to Headquarters are amplified below:

a. As noted on the attached charts, the flight test program for aircraft number one and two, in accordance with SP-2073, is scheduled for completion in March. However, within this time period neither the "H" camera nor the tracker camera will be tested due to a slippage in the delivery schedules for the hatch windows.

b. Windows and hatches for sensor systems are pacing items for compatibility flight tests scheduled to begin 28 February 1968. Glass for the first "B" hatch received by Hycon 5 February 1968. The second set is due 15 February; third set 29 February; and two sets per month thereafter. Efforts are being made to improve this schedule. Glass for 1st Delta III hatch is on hand at Lockheed, the second set is completed at Lexington and awaiting call by Lockheed. First set of tracker glass due 8 March 1968 at outside, every effort being made to improve this date. Window glass for the H camera - 1st set is due 30 March and 2nd set 30 May 1968. One set of glass blanks for "H" camera is included. Glass for windows and hatches will be delivered at a rate greater than that of the vehicles permitting the glass to catch up at about the seventh vehicle.

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c. [redacted] Some of the new systems will require major wiring and design changes both in the aircraft and in the black boxes. Headquarters immediate action is required to resolve the problem. 25X1

d. On flight 26 of aircraft number one, the pilot experienced a very noticeable shaking in the aft end of the fuselage at altitude =37,000 feet, V=234 knots and M=.74. Both stabilizer tips were instrumented and the data revealed an 18 cycle per second vibration which equates to approximately 9 G's acceleration. This vibration lasted for 19 seconds. Lockheed was able to simulate this phenomena on their computer by reducing the calculated elevator stiffness by a factor of two. However, if what actually occurred was pure flutter, the deflections associated with the 18 CPS vibration should have resulted in complete destruction of the tail in a very few seconds unless there were compensating factors. Therefore LAC is theorizing that the stiffness of the elevator and its control bar varies with amplitude such that as amplitude increases, stiffness increases, and shifts the critical flutter speed to a higher value than the flight speed at the time of the incident. LAC has coined the phrase "limit cycle" to identify this bounded variation of stiffness versus amplitude. To prove or disprove the theory, LAC will measure the elevator stiffness as a function of deflection in ground tests. These data will then be inserted in the computer and the flutter characteristics will be recomputed. Until these results are determined and a fix is assigned, the aircraft is restricted to a maximum speed of 210 knots at 37,000 feet altitude.

e. The numerous hydro pump compensator failures have been traced to pressure fluctuations which occur during no-flow conditions. There is no hydro flow in normal cruise flight for the U-2R as contrasted with the U-2C where the fuel boost pump is driven by a hydraulic motor. "Fort" testing has determined that a small bleed flow smooths out the pump considerably. Therefore, a bleed line with a flow-limiting orifice has been installed in aircraft number one and preliminary analysis of flight test data indicates a considerable improvement in pump roughness characteristics. In addition, LAC is working closely with Vickers on a damped accumulator for the pump output line to smooth out the pressure fluctuations.

f. The recent loss of both the primary brake system and the emergency brake system has resulted in a redesign of the emergency system so that it operates independent of electrical power. This design change consisted of replacing the normally closed brake accumulator shut-off valve with a normally open valve. Electrical D.C. power now will close the valve during flight to protect the system against leakage until touchdown. After touchdown and when a prescribed load is on the landing gear, a scissors switch will cut off the D.C. power and the accumulator valve will open.

g. Instrumented data from flight 21 of aircraft number one indicate excellent agreement with the predicted values for maximum power cruise range factors and altitudes. These data give added confidence that the specification performance of 3901 n.m. at 67,500 [redacted] 25X1
feet altitudes for design and overload gross weights respectively will probably be met.

h. LAC test pilot [redacted] will not fly with 25X1
the prototype pressure suit offered by Headquarters because the breathing regulators

interfere with his neck. (It was pointed out by Headquarters that in spite of several invitations for LAC to submit their requirements for properly fitted full pressure suits, they declined to do so.) He will therefore continue to use his SR-71 suit and will be restricted to flights of approximately eight hours duration. LAC
25X1 pilots [redacted] will fly with the prototype suit as required to demonstrate the long duration mission profiles.

i. A test will be conducted to determine if the air which is passed over the liquid oxygen converters after passing through the 718T HF radio will be warm enough in the event of an HF failure.

j. The constant speed drive (CSD) which is coupled to an engine-driven generator has a thermal disconnect in the event of excessive heat. This performs the same function as a "wax" shaft.

k. The decision was made to distribute all of the contractual technical documents, such as the flight handbook, through the depot. Therefore LAC will transmit all of these data to the depot for subsequent distribution and advance copies for Headquarters personnel will not be available.

3. Propulsion System Status

Status of Engine Oil Cooling Problem

The fuel/oil cooler appears to be the final solution to the engine/oil cooling problems which have arisen out of the inability of the air/oil cooler to sufficiently cool the oil to keep the oil temperature to the engine from exceeding the allowable maximum temperature of 121°c.

The critical combination of conditions which will determine if the engine oil is adequately cooled will be high fuel onload temperature, with a light take off gross weight (fast rate of climb) which will reduce the fuel-oil cooler performance and hot day, high altitude flight conditions which will reduce performance of the air/oil cooler.

Heat transfer analyses conducted by LAC engineers indicate that the air/oil cooler, fuel/oil cooler combination will adequately cool the oil even for the above critical combination of conditions. These analyses are based on measured fuel temperatures taken some time ago on a U-2C parked in the sun under hot day conditions and corrected for the U-2R to obtain maximum expected on-load fuel temperatures. Fuel cool-down rates were based on flight test data taken on the number one U-2R (silver aircraft) and are corrected for the higher solar heat load (3.0 Btu/min/ft^2) which would be expected with a black aircraft. The final test of the oil cooling system will involve simulation of various flight profiles with the number three aircraft which will be painted black.

The supply problem with regard to available fuel oil coolers is rather critical with a known total of six available coolers at P/W or installed in aircraft. Aircraft number one and number three now have the fuel/oil coolers installed with the jury rigged LAC arrangement where the fuel/oil cooler is mounted to the airframe rather than the engine. An additional 16 fuel oil coolers have been located in Air Force inventories (the same fuel/oil cooler is used on the F-105 aircraft). These are reported to be in a repairable condition so their availability is rather uncertain.

Two preliminary sets of the plumbing required for the final arrangement where the fuel/oil cooler is installed on the engine are now available. One of these sets is to be used for an LAC mock up check and one for a functional check on an engine in East Hartford. The lead time for this plumbing once the final approved design is released to production is reported to be about six months.

A portion of the propulsion system flight test program which must be completed as soon as possible involves engine operating envelope determination. These tests are estimated to require about four or five flights and include maximum and minimum EPR (engine pressure ratio) schedules at various flight conditions and engine relight envelope.

The inlet total pressure recovery data that was obtained in flight before the air cooling duct cover caused a severe FOD of the instrumented engine indicates a very favorable level of inlet pressure recovery with values of P_{T2}/P_{TO} (Ratio of average engine face total pressure to ambient pressure plus ram effect) as high as 99%.

Flight test data taken to date also indicates a relatively good match of EGT and EPR at a given flight condition. Since EPR is a general indication of engine thrust output the two parameters indicate whether or not the engine is operating at its proper EGT for a given thrust output. Flight test values are in reasonably good agreement with the EGT-EPR values measured in the Navy Trenton Lab tests with the -13B engine. Values of the square root of the corrected absolute Exhaust Gas Temperature, which is the significant temperature parameter for a choked exhaust nozzle are running about 2% greater than Trenton test values for the same EPR and flight condition. This slight difference can be accounted for by the fact that the actual nozzle area now being used is about 2% smaller than that used at Trenton. Trenton tests were also run without any accessory drive loads and aircraft required high pressure compression air bleed.

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